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FROM SIZE SORTING OF CHONDRULES TO ACCRETION OF PARENT BODIES—THE EFFECTS OF PHOTOPHORESIS

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Introduction: Recent evidence based on ^{26}Al chronology suggest that the differentiated asteroids accreted ~0.7 Myr after CAI formation, while chondrules were still forming in the nebula [1]. Chondrules appear to have been size-sorted prior to accretion [2], suggesting that physical processes allowed rapid accretion of some asteroids while components of other asteroids formed and were being size-sorted at the same time. Observations of asteroids and theoretical models suggest that the differentiated asteroids formed closer to the Sun than primitive asteroids, possibly in the terrestrial planet forming region [3]. We believe that several of these observations could be attributed to photophoresis, which have recently been shown to be of significance while gas and dust coexisted in the solar nebula [4].

Chondrule and CAI-Based Constraints: Several clues to the sorting and concentration processes come from the observations of chondrules and CAIs in chondrites. 1) Chondrules are better sorted than CAIs [5]. If the sorting process was operating on a small scale we should expect that all of the locally available components were equally well sorted. We thus infer that the sorting process was operating on a large scale. 2) Chondrules are common in all types of equilibrated chondrites whereas CAIs are only common in carbonaceous chondrites, 3) CAIs apparently formed close to the Sun but are mainly found in carbonaceous chondrites believed to originate in the outer part of the asteroid belt. 4) Differences in oxygen isotope signatures show that the source regions for ordinary, enstatite, and carbonaceous chondrites were separated from each other in space and/or time.

Photophoresis and Size Sorting in the Nebula: We suggest that photophoresis could have two significant effects on the particle motion in the solar nebula. In the early stages while the nebula was still optically thick photophoresis would help concentrate particles at the inner edge of the disk leading to enhanced accretion rates here [6]. As the nebula became optically thin photophoresis pushed chondrules and CAIs out to the point were inward motion caused by gas drag is balanced by the outward motion caused by photophoresis and radiation pressure. The particles will drift toward the radial distance where the forces balance and since the photophoresis is a size dependent force, different size ranges of chondrules and CAIs will accumulate and subsequently accrete at different heliocentric distances. As the gas gets thinner and thinner the accumulation point will move inward [7]. The first chondritic bodies will therefore accrete in the outer parts of the belt and probably include the majority of the remaining CAIs. As the accumulation point moves inward, later generations of chondrules will be incorporated in chondrite parent bodies largely devoid of CAIs, in the inner part of the asteroid belt.

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MASS-FRACTIONATION INDUCED BY THE GENESIS SOLAR WIND CONCENTRATOR: ANALYSIS OF NEON ISOTOPES BY UV LASER ABLATION

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The solar wind (SW) concentrator, a key instrument onboard the Genesis mission, was designed to provide larger fluences of implanted SW for precise isotope analyses of oxygen and nitrogen [1]. SW ions in the mass range 4–28 amu were accelerated and focused on a “concentrator target” by an electrostatic mirror. This concentration process caused some instrumental mass fractionation of the implanted SW ions as function of the radial position on the target. Correction of this fractionation will be based on a combination of the measured radial fractionation of Ne isotopes with results of simulations of the implantation process using the actual performance of the concentrator and the SW conditions during exposure. Here we present He and Ne abundance and Ne isotopic composition data along one arm of the gold cross that framed the 4 concentrator subtargets.

He and Ne were released from pits ~120 μm in diameter by UV laser ablation using a 248 nm Eximer laser [2]. In the first 34 analyses, He and Ne were analyzed together at constant analytical conditions. In a second set of 16 analyses, He and Ne were separated to protect the mass spectrometer from solar ^{3}He. In total, 12 positions along the arm (30 mm long) were analyzed, each with 1 to 6 single analyses. He and Ne abundances increase from the edge (at 30 mm) towards the center of the concentrator cross, He from 5.3E+15 ions/cm^2 (at 20.5 mm) to 1.8E+16 ions/cm^2 (at 2.9 mm) and Ne from 3.5E+12 ions/cm^2 (at 29.4 mm) to 3.4E+13 ions/cm^2 (at 1 mm). Thus, the concentration factor increases by about a factor of 10, similar to expected values from post-flight models for oxygen. Applying a simplified backscatter correction measured and expected Ne abundances agree within 20%. The measured Ne isotopes show a large mass fractionation as function of the target radius. The ^{22}Ne values (relative to SW ^{20}Ne/^{22}Ne of 13.75, [3]) range from −19‰ (at 26 mm) to +40‰ (at 2.9 mm), reflecting a preferential implantation of the heavier isotopes towards the center of the concentrator target. Precision of the ^{20}Ne/^{22}Ne ratios, expressed as error of the mean, is on average 4‰ (2σ) for the analyses in which He and Ne were not separated. More work is needed to reduce the considerably larger scatter observed so far in the analyses where He and Ne were separated. The obtained Ne isotope fractionation curve resembles, in shape and extent of fractionation, the post-flight modeled δ^{18}O curve. The two curves are offset by about 10‰. This is probably to be explained by the missing backscatter correction for the measured Ne isotopes. At the conference we will compare measured Ne data with simulated results of Ne implantation at SW conditions prevalent during Genesis collection period.

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